US007982405B2

(12) **United States Patent**
Patchornik

(10) **Patent No.: US 7,982,405 B2**
(45) **Date of Patent: Jul. 19, 2011**

(54) **IGNITER CIRCUIT FOR AN HID LAMP**

(75) Inventor: **Joshua Patchornik**, Ramat Gan (IL)

(73) Assignee: **Lightech Electronic Industries Ltd.**, Lod (IL)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 694 days.

(21) Appl. No.: **11/909,341**

(22) PCT Filed: **Dec. 6, 2005**

(86) PCT No.: **PCT/IL2005/001309**
§ 371 (c)(1),
(2), (4) Date: **Sep. 21, 2007**

(87) PCT Pub. No.: **WO2006/100661**
PCT Pub. Date: **Sep. 28, 2006**

(65) **Prior Publication Data**

US 2010/0141164 A1 Jun. 10, 2010

(30) **Foreign Application Priority Data**

Mar. 22, 2005 (IL) 167582

(51) **Int. Cl.**
H05B 41/36 (2006.01)

(52) **U.S. Cl.** **315/224**

(58) **Field of Classification Search** .... 315/224, 315/209 R, 219, 246, 209 T, 291, 307
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,636,374 A 1/1972 Sumi
3,735,398 A 5/1973 Ross
3,760,414 A 9/1973 Nicolson
3,903,891 A 9/1975 Brayshaw
3,997,814 A 12/1976 Toho
4,005,336 A 1/1977 Casella
4,007,416 A 2/1977 Szatmari
4,076,420 A 2/1978 De Maeyer
4,095,140 A 6/1978 Kirkhuff
4,253,046 A 2/1981 Gerhard
4,266,165 A 5/1981 Handler
4,277,728 A 7/1981 Stevens
4,289,993 A 9/1981 Harper
4,318,031 A 3/1982 Lonseth
4,320,326 A 3/1982 Banziger
4,323,149 A 4/1982 Wyner
4,334,172 A 6/1982 Wyner
4,717,863 A 1/1988 Zeiler

(Continued)

FOREIGN PATENT DOCUMENTS

EP 0233605 A2 2/1987

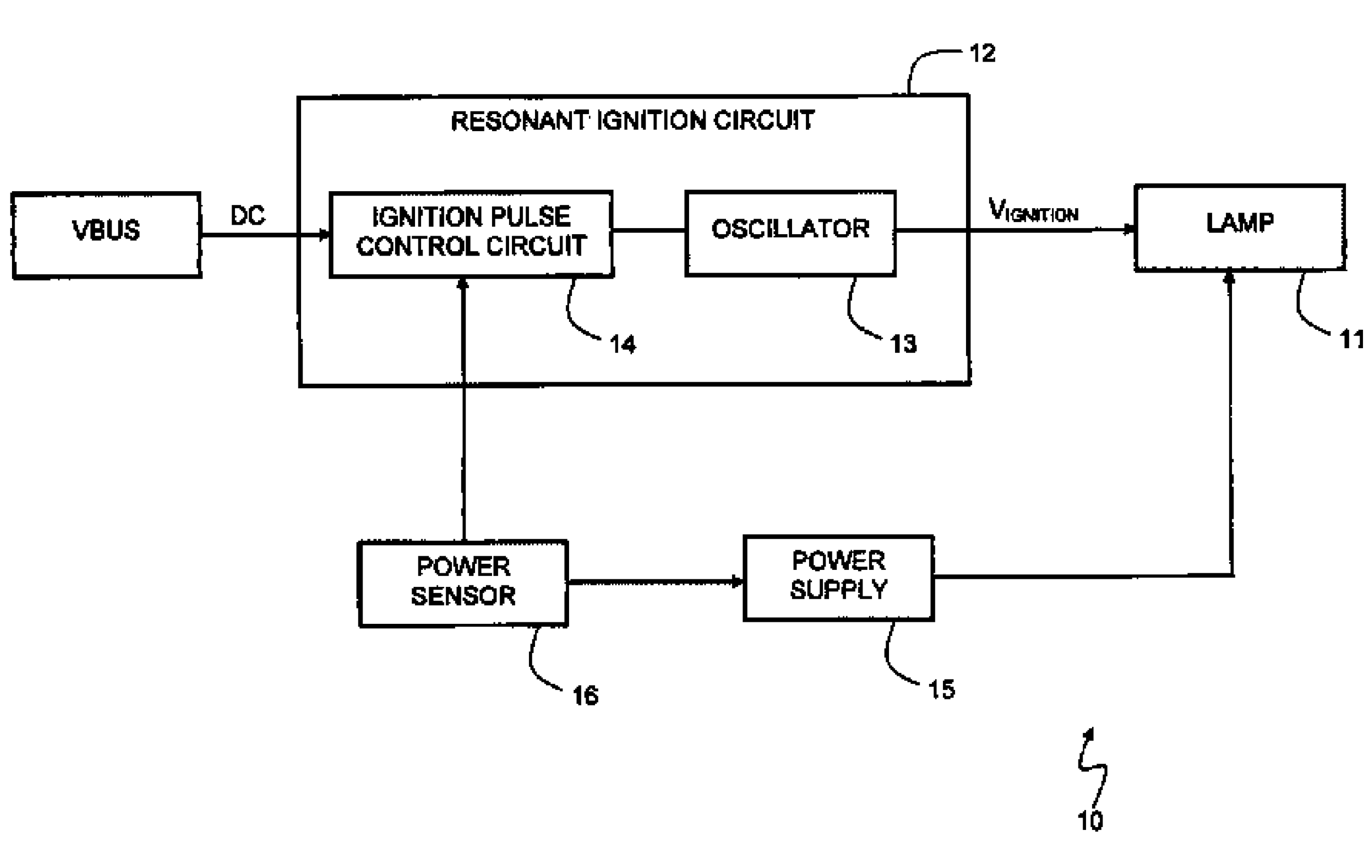
(Continued)

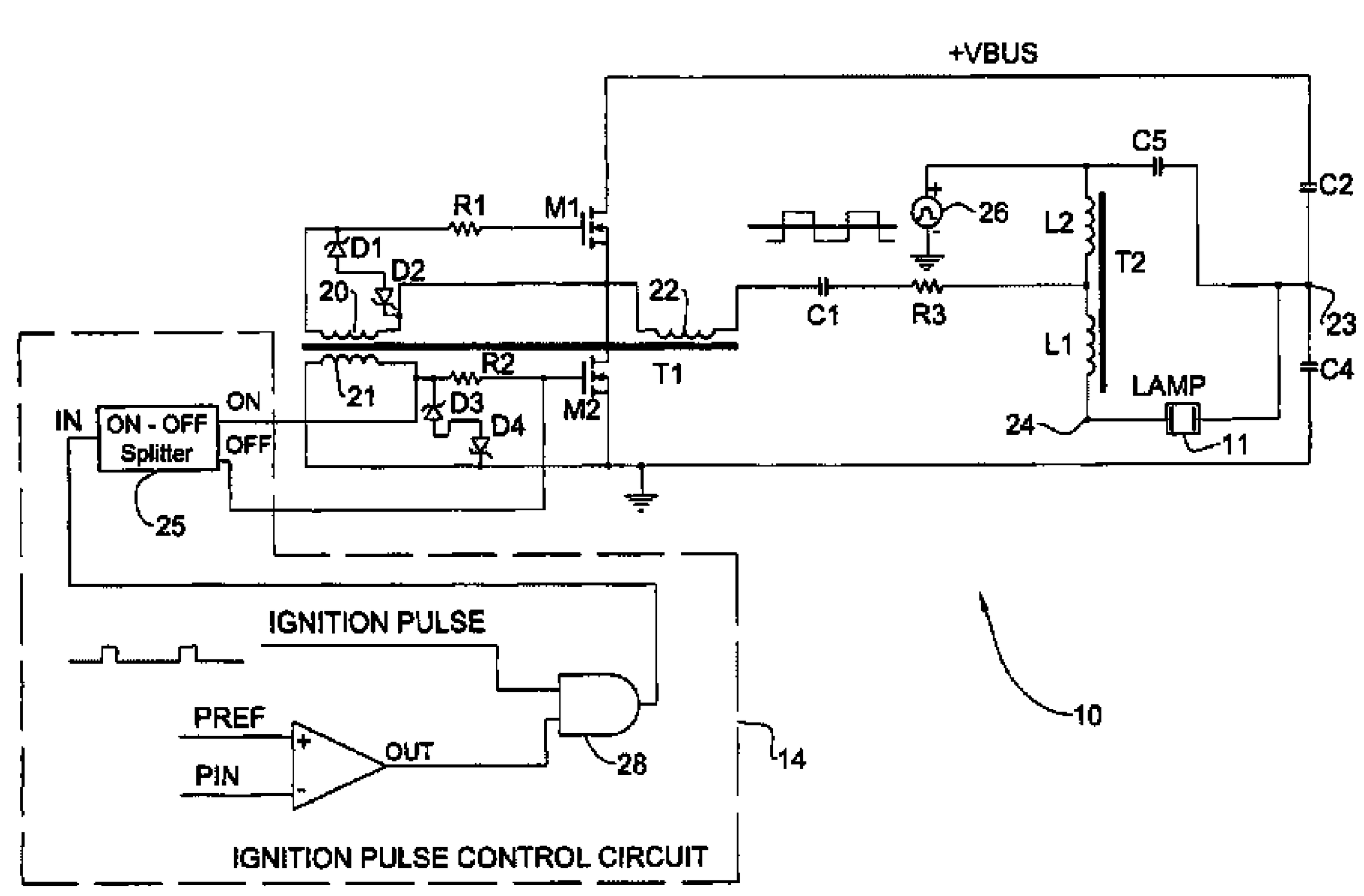
Primary Examiner — Douglas W Owens
Assistant Examiner — Minh D A
(74) *Attorney, Agent, or Firm* — Browdy and Neimark, PLLC

(57) **ABSTRACT**

An igniter circuit (**10**) for an HID lamp (**11**) has a DC input (VBUS) for coupling to a source of DC voltage, and an output (**23**, **24**) for coupling to the HID lamp. A resonant ignition circuit (**12**) operating at a controlled resonant frequency is coupled to the DC input for producing successive bursts of voltage having a frequency equal to the resonant frequency and having an amplitude that increases with time. The resonant ignition circuit (**12**) feeds the bursts of voltage across the output of the igniter until an HID lamp coupled thereto reaches breakdown.

16 Claims, 3 Drawing Sheets





U.S. PATENT DOCUMENTS

4,727,297	A	2/1988	Wolze	
4,763,044	A	8/1988	Nuckolls	
4,781,175	A	11/1988	McGreevy	
4,795,945	A	1/1989	Mayer	
4,862,039	A	8/1989	Kile	
4,888,528	A	12/1989	Byszewski	
4,896,077	A	1/1990	Dodd	
4,904,903	A	2/1990	Pacholok	
4,912,374	A	3/1990	Nagase	
4,920,300	A	4/1990	Scott	
4,952,845	A	8/1990	Veldman	
4,958,107	A	9/1990	Mattas	
4,959,593	A	9/1990	Joanins	
4,962,336	A	10/1990	Dodd	
4,983,889	A	1/1991	Roberts	
4,996,464	A	2/1991	Dodd	
5,053,681	A	10/1991	Budny	
5,057,750	A	10/1991	Farrall	
5,101,142	A	3/1992	Chatfield	
5,103,140	A	4/1992	Cocorna	
5,175,476	A	12/1992	Anderson	
5,192,897	A	3/1993	Vossough	
5,225,742	A	7/1993	Beasley	
5,229,927	A	7/1993	Vila-Masot	
5,319,286	A	6/1994	Laytem	
5,331,253	A	7/1994	Counts	
5,365,151	A	11/1994	Spiegel	
5,365,152	A	11/1994	Ozawa	
5,396,152	A	3/1995	Bognigk	
5,424,617	A	6/1995	Garbowicz	
5,428,268	A	6/1995	Melis	
5,430,354	A	7/1995	Garbowicz	
5,444,333	A	8/1995	Lau	
5,453,667	A	9/1995	Matsuda	
5,483,127	A	1/1996	Widmayer	
5,608,296	A	3/1997	Brown	
5,615,093	A	3/1997	Nalbant	
5,615,100	A	3/1997	Radecker	
5,623,187	A	4/1997	Caldiera	
5,631,523	A	5/1997	Rothenbuhler	
5,708,330	A	1/1998	Rothenbuhler	
5,736,817	A	4/1998	Rothenbuhler	
5,751,120	A	5/1998	Zeitler	
5,801,494	A	9/1998	Herres	
5,806,055	A	9/1998	Zinda	
5,825,138	A	10/1998	Diazzi	
5,886,481	A	3/1999	Flory	
5,914,571	A	6/1999	Beasley	
5,917,287	A	6/1999	Haederle	
5,936,358	A	8/1999	Okamoto	
5,945,784	A	8/1999	Mattas	
5,945,787	A	8/1999	Gorille	
5,949,192	A	9/1999	Kominami	
5,955,843	A	9/1999	Nuckolls	
5,962,985	A	10/1999	Buij	
5,962,987	A	10/1999	Statnic	
5,982,108	A	11/1999	Buij	
5,986,412	A	11/1999	Collins	
5,990,599	A	11/1999	Jackson	
5,990,634	A	11/1999	Brown	
5,994,846	A	11/1999	Blankers	
6,011,360	A	1/2000	Gradziki	
6,020,691	A	2/2000	Sun	
6,028,397	A	2/2000	Blankers	
6,031,340	A	2/2000	Brosius	
6,075,326	A	6/2000	Nostwick	
6,091,208	A	7/2000	Flory	
6,100,649	A	8/2000	Shoshan et al.	
6,100,652	A	8/2000	Konopka	
6,111,359	A	8/2000	Work et al.	
6,114,814	A	9/2000	Shannon	
6,144,171	A	11/2000	Clements	
6,144,172	A	11/2000	Sun	
6,157,142	A	12/2000	Moisin	
6,160,362	A	12/2000	Shone	
6,181,076	B1	1/2001	Trestman	
6,188,180	B1	2/2001	Diamond	
6,194,845	B1	2/2001	Konopka	
6,239,559	B1	5/2001	Okamoto	
6,259,215	B1	7/2001	Roman	
6,259,615	B1	7/2001	Lin	
6,294,880	B1	9/2001	Deurloo	
6,304,041	B1	10/2001	Farkas	
6,316,881	B1	11/2001	Shannon	
6,316,885	B1	11/2001	Collins	
6,316,887	B1	11/2001	Ribarich	
6,329,761	B1	12/2001	Melis	
6,344,717	B1	2/2002	Lestician	
6,359,393	B1	3/2002	Brown	
6,359,394	B1	3/2002	Stein	
6,369,518	B1	4/2002	Kelly	
6,369,526	B1	4/2002	Pogadaev	
6,373,199	B1	4/2002	Erhardt	
6,376,999	B1	4/2002	Li	
6,380,694	B1	4/2002	Uchihashi et al.	
6,392,365	B1	5/2002	Zhou et al.	
6,396,722	B2	5/2002	Lin	
6,417,625	B1	7/2002	Brooks	
6,429,597	B1	8/2002	Flory	
6,437,515	B1	8/2002	Kamoi et al.	
6,448,720	B1	9/2002	Sun	
6,483,257	B1	11/2002	Henderson	
6,498,437	B1	12/2002	Chang	
6,504,313	B1	1/2003	Shen	
6,518,712	B2 *	2/2003	Weng	315/209 R
6,525,491	B2	2/2003	Huber	
6,555,972	B1	4/2003	Lestician	
6,593,703	B2	7/2003	Sun	
6,597,128	B2	7/2003	Flory	
6,608,450	B2	8/2003	Lestician	
6,608,451	B2	8/2003	Collins	
6,628,090	B1	9/2003	Scollo	
6,633,138	B2	10/2003	Shannon	
6,642,673	B2	11/2003	Hudson	
6,650,067	B1	11/2003	Shloush	
6,664,790	B2	12/2003	Cook	
6,667,587	B1	12/2003	Chang	
6,683,422	B1	1/2004	Moyer	
6,696,803	B2	2/2004	Tao	
6,707,263	B1	3/2004	Prasad	
6,734,637	B2	5/2004	Ellams	
6,756,747	B2	6/2004	Hsieh	
6,781,327	B2	8/2004	Ohsawa	
6,804,129	B2	10/2004	Lin	
6,822,401	B2	11/2004	Borella	
6,965,204	B2 *	11/2005	Langeslag	315/209 R
7,110,267	B2 *	9/2006	Lurkens	363/21.02
7,486,028	B2 *	2/2009	Langeslag et al.	315/209 R
2001/0030515	A1	10/2001	Huber	
2002/0047547	A1	4/2002	Flory	
2002/0047609	A1	4/2002	Weng	
2002/0074952	A1	6/2002	Hudson	
2002/0121866	A1	9/2002	Ellams	
2002/0140370	A1	10/2002	Sun	
2002/0145393	A1	10/2002	Hui	
2002/0167281	A1	11/2002	Buij	
2002/0171376	A1	11/2002	Rust	
2002/0180383	A1	12/2002	Gong	
2002/0190665	A1	12/2002	Sun	
2003/0006720	A1	1/2003	Borella	
2003/0038602	A1	2/2003	Lestician	
2003/0062853	A1	4/2003	Flory	
2003/0080694	A1	5/2003	Collins	
2003/0137257	A1	7/2003	Collins	
2003/0137260	A1	7/2003	Ohsawa	
2003/0161164	A1	8/2003	Shannon	
2003/0222586	A1	12/2003	Brooks	
2004/0061454	A1	4/2004	Prasad	
2004/0095076	A1	5/2004	Kastle	
2004/0113570	A1	6/2004	Ribavich	
2004/0130374	A1	7/2004	Dulaney	
2004/0155607	A1	8/2004	Rust	
2004/0183463	A1	9/2004	Sun et al.	
2004/0207335	A1	10/2004	Nerone	
2004/0257002	A1	12/2004	Gerardus	
2004/0257004	A1	12/2004	Deurloo	

FOREIGN PATENT DOCUMENTS

EP	0253163	A2	1/1988
EP	0291223	A1	5/1988
EP	0314077	A2	10/1988
EP	0383385	A1	8/1990
EP	0536535	A1	3/1992
EP	0577105	A1	6/1993
EP	0566310	A1	10/1993
EP	0566815	A	10/1993
EP	0664663	A1	1/1994
EP	0595414	A2	5/1994
EP	0613326	A1	8/1994
EP	0638918	A1	2/1995
EP	0650313	A2	4/1995
EP	0719591	A2	7/1996
EP	0766499	A1	4/1997
EP	0831517	A2	3/1998
EP	0868115	A2	9/1998
EP	0975204	A1	1/2000
EP	1077591	A2	2/2001
EP	1239708		3/2002
EP	1206169	A2	5/2002
EP	1225791	A2	7/2002
EP	1227706	A2	7/2002
EP	1367864	A	12/2003
EP	1404163	A2	3/2004
EP	1379112	A1	7/2004
EP	1427263	A1	9/2004
JP	01251597	A	6/1989
JP	4292898	A	10/1992
JP	4292899	A	10/1992
JP	04308691	A	10/1992
JP	05047484	A	2/1993
JP	05290988	A	5/1993
JP	6029006	A	2/1994
JP	06132087	A	5/1994
JP	70006888	A	1/1995
JP	08273856	A	10/1996
JP	10270188		10/1998
JP	200012251	A	1/2000
JP	2002260886		9/2002
JP	2002373511		12/2002
JP	200317284	A	1/2003
JP	2003163093		6/2003
JP	2003187996	A1	7/2003
WO	83/02537	A1	7/1983
WO	93/14559	A	7/1993
WO	95/01712	A1	1/1995
WO	9604770	A1	2/1996
WO	96/20578	A2	7/1996
WO	96/25022	A1	8/1996
WO	97/11580	A1	3/1997
WO	97/11583	A1	3/1997
WO	97/11585	A1	3/1997
WO	97/11586	A1	3/1997
WO	97/38561	A1	10/1997
WO	97/42795	A1	11/1997
WO	98/07301	A1	2/1998
WO	98/28836	A1	7/1998
WO	98/51133	A2	11/1998
WO	99/05735	A1	2/1999
WO	99/30538		6/1999
WO	99/30538	A1	6/1999
WO	99/40757	A1	8/1999
WO	00/22889	A2	9/1999
WO	00/21341	A1	4/2000
WO	00/59268	A1	10/2000
WO	00/69224	A1	11/2000
WO	01/33916	A1	5/2001
WO	01/47325	A1	6/2001
WO	02/13222	A1	2/2002
WO	02/23958	A	3/2002
WO	02/23959	A1	3/2002
WO	02/28152	A1	4/2002
WO	02/32194	A2	4/2002
WO	02/49399	A1	6/2002
WO	02/060228	A1	8/2002
WO	02/080630		10/2002
WO	02/087290	A1	10/2002
WO	02/104083		12/2002
WO	03/037043	A1	5/2003
WO	03/058590	A1	7/2003
WO	03/058591	A1	7/2003
WO	03/060619	A1	7/2003
WO	03/098978	A1	11/2003
WO	2004/008814	A1	1/2004
WO	2004/010743	A1	1/2004
WO	2006/100661	A1	9/2006

* cited by examiner

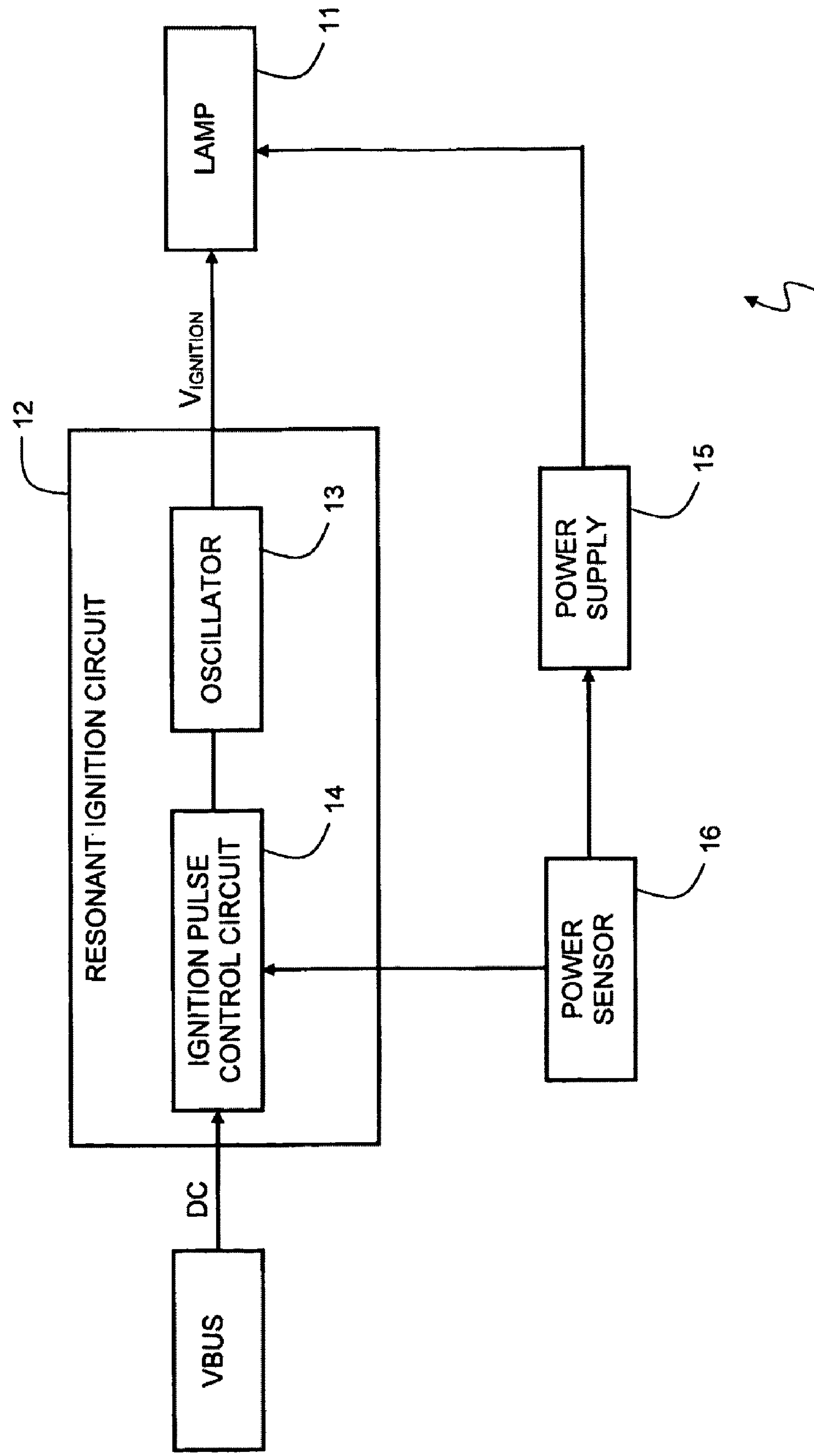

LAMP
11
$V_{IGNITION}$
12
RESONANT IGNITION CIRCUIT
OSCILLATOR
13
IGNITION PULSE CONTROL CIRCUIT
14
DC
VBUS
POWER SUPPLY
15
POWER SENSOR
16
10

FIG. 1

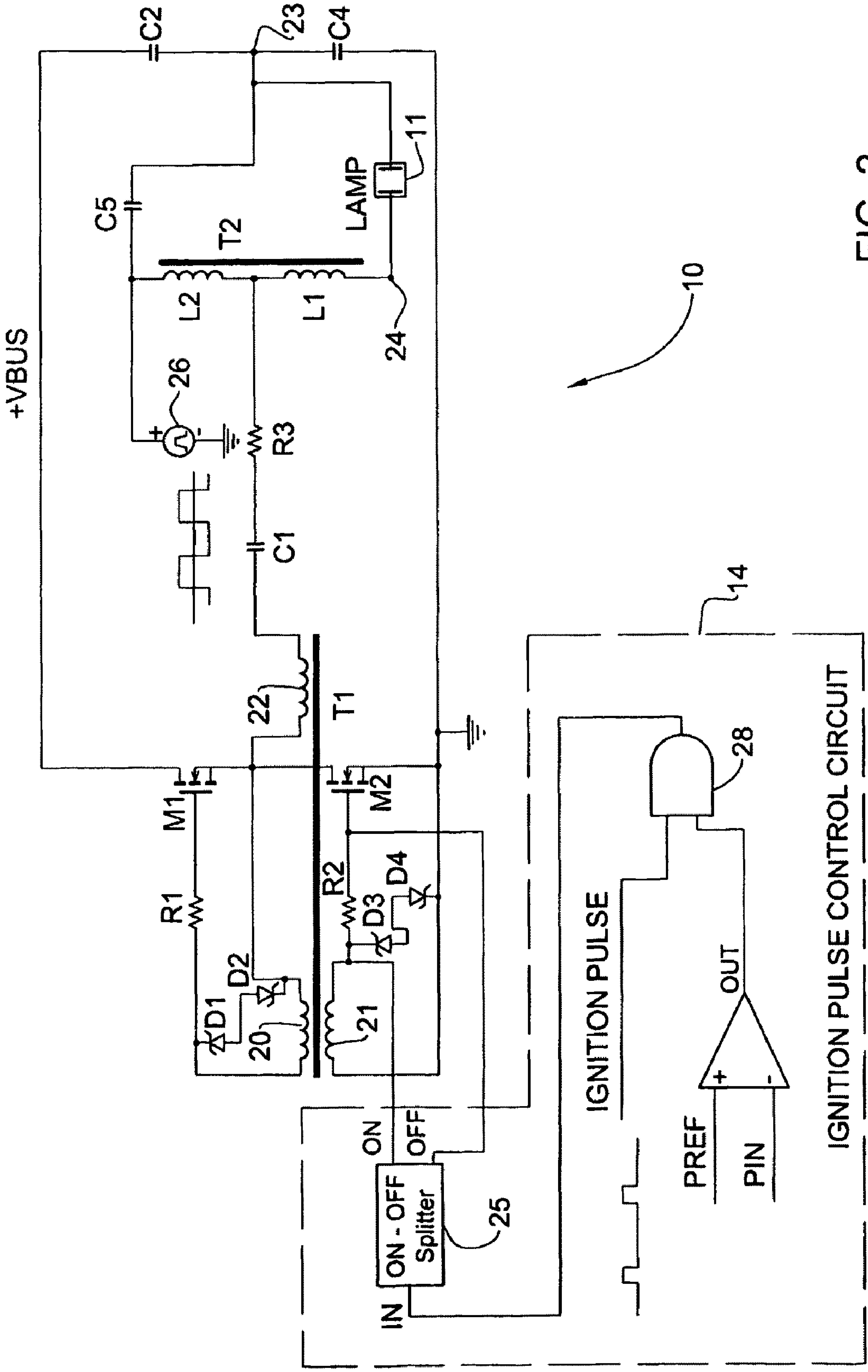

C2
23
C4
11
LAMP
C5
T2
L2
L1
24
10
+VBUS
26
R3
C1
22
T1
M1
M2
R1
R2
D1
D2
D3
D4
20
21
14
28
IGNITION PULSE CONTROL CIRCUIT
IGNITION PULSE
OUT
PREF
PIN
ON
OFF
ON - OFF Splitter
25
IN

FIG. 2

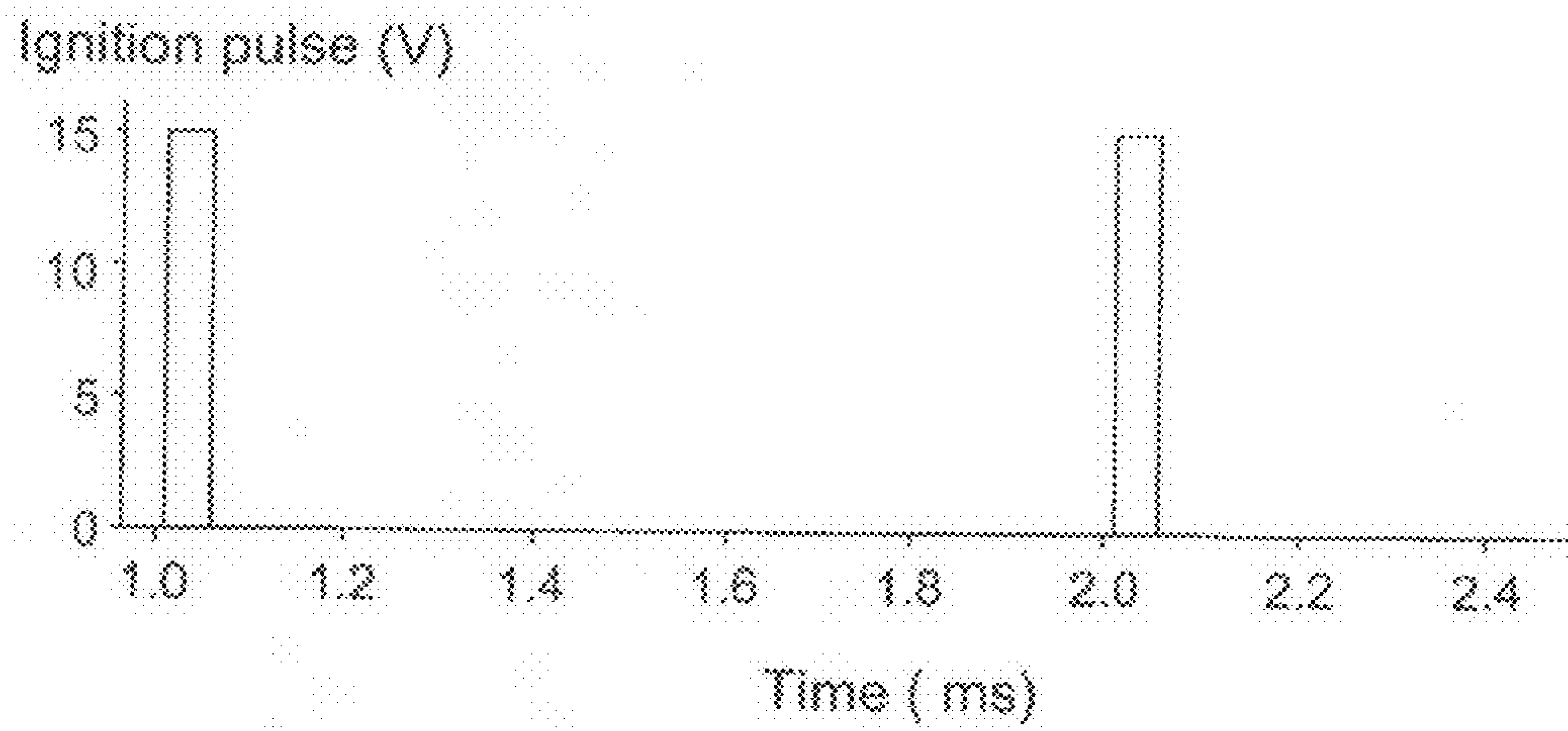

Ignition pulse (V)
15
10
5
0
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
Time (ms)

FIG. 3

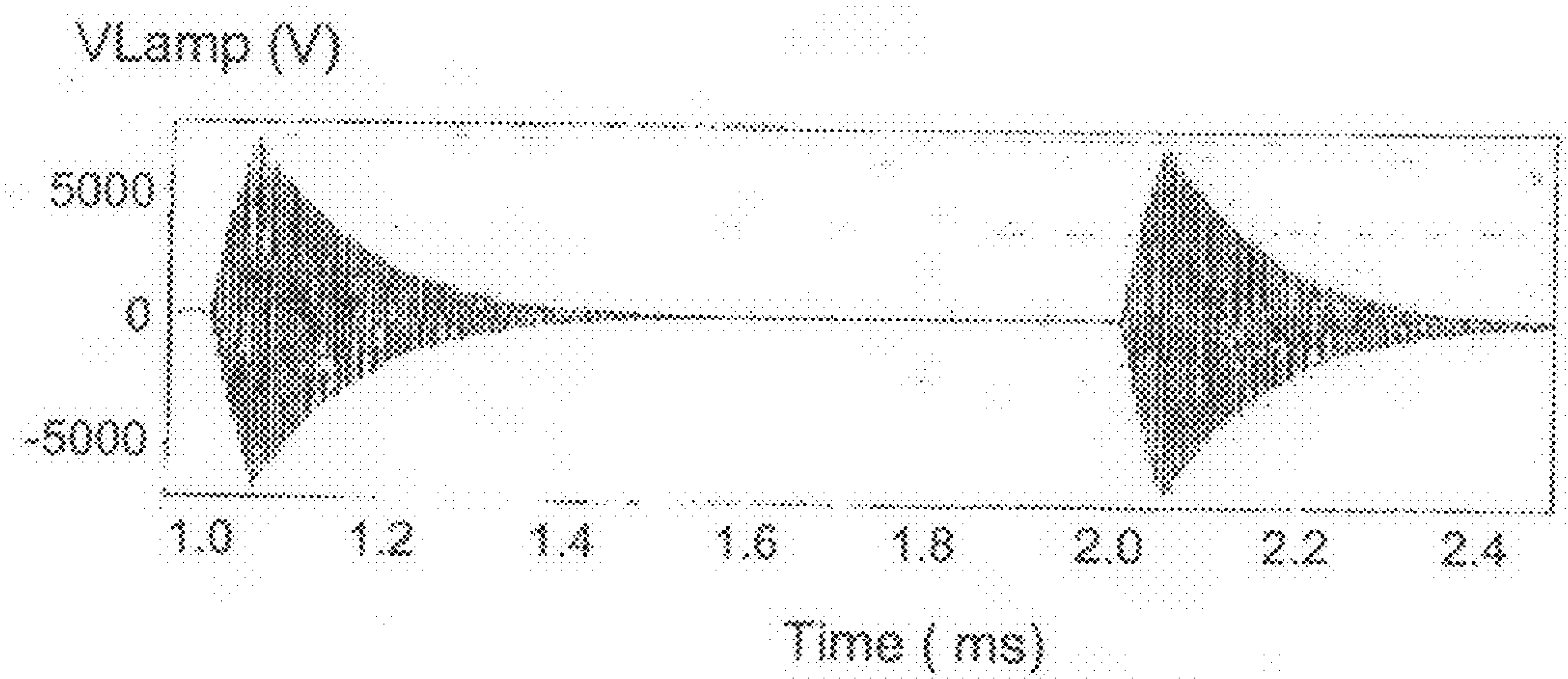

VLamp (V)
5000
0
-5000
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
Time (ms)

FIG. 4

IGNITER CIRCUIT FOR AN HID LAMP

FIELD OF THE INVENTION

This invention relates to igniters for high intensity discharge lamps.

BACKGROUND OF THE INVENTION

The function of a high-intensity discharge (HID) electronic ballast is to supply ignition to the lamp for starting and then operating the lamp, such as a metal halide lamp. A metal halide lamp is a gas discharge lamp in which metal halides are enclosed, for example, in a quartz envelope.

To initiate its operation, a metal halide lamp demands a high ignition voltage. Once the lamp is ignited, the voltages falls to low voltage of the order of 20 V and the lamp it is then maintained for a short time (typically between 1-2 minutes) in so-called "current mode" where the current is constant and the voltage rises until the lamp reaches nominal power, whereafter the ballast serves to stabilize the power.

Prior art igniter circuits are known where an uncontrolled oscillator frequency is swept from a frequency that is less than the resonant frequency such that when it reaches resonance the voltage reaches maximum value and the lamp strikes. However, during this operation the frequency continues to rise and the voltage therefore falls.

SUMMARY OF THE INVENTION

It is an object of the invention to provide an igniter circuit for an HID lamp that employs a self-oscillating power supply for applying across the lamp a high ignition voltage that increases with time.

It is a further object to provide such an igniter circuit that is configured for coupling directly to an inverter having a half bridge topology for feeding low frequency current to the lamp after ignition.

These objects are realized in accordance with a first aspect of the invention by an igniter circuit for an HID lamp, the igniter circuit comprising:

a DC input for coupling to a source of DC voltage,

an output for coupling to the HID lamp, and

a resonant ignition circuit operating at a controlled resonant frequency coupled to said DC input for producing successive bursts of voltage having a frequency equal to the resonant frequency and having an amplitude that increases with time and for feeding said bursts of voltage across the output of the igniter until an HID lamp coupled thereto reaches breakdown.

According to a second aspect of the invention, there is provided a method for igniting a HID lamp, the method comprising:

using a resonant circuit connected across the lamp to generate successive bursts of voltage having a frequency equal to the resonant frequency and having an amplitude that increases with time; and

applying said bursts of voltage across the HID lamp until the lamp ignites, thereby loading the resonant circuit so that its Q factor falls sufficiently to stop the resonant circuit resonating.

BRIEF DESCRIPTION OF THE DRAWINGS

In order to understand the invention and to see how it may be carried out in practice, a preferred embodiment will now be described, by way of non-limiting example only, with reference to the accompanying drawings, in which:

FIG. **1** is a block diagram showing the functionality of an igniter circuit for an HID lamp in accordance with an exemplary embodiment of the invention;

FIG. **2** is a schematic circuit diagram of the igniter circuit shown functionally in FIG. **1**;

FIG. **3** is a waveform showing graphically a series of ignition pulses fed to the with the igniter circuit shown in FIG. **2**; and

FIG. **4** is a waveform showing graphically a resonant frequency voltage whose amplitude increases with time and that is applied to the HID lamp prior to ignition.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

FIG. **1** is a block diagram showing the functionality of an igniter circuit **10** according to the invention for an HID lamp **11**. The igniter circuit **10** is operated from a DC power source, VBUS, which is not itself part of the igniter circuit **10** and may be generated in manner well known to those skilled in the art. The DC power source, VBUS, is fed to a controlled self-oscillator **12** comprising a self oscillator **13** controlled by an ignition pulse control circuit **14**. The HID lamp **11** is coupled to the controlled self-oscillator **12** which constitutes an igniter circuit for igniting the lamp. The lamp is powered by a power supply **15**, which conveniently is coupled to the DC power source, VBUS, although it could be independent thereof. In order to disable operation of the igniter circuit after ignition of the HID lamp **11**, a power sensor **16** is responsively coupled to the DC power source, VBUS, so as to sense the current supplied thereby. Before the lamp **11** ignites the current sensed by the power sensor **16** is low; but once the lamp **11** ignites it draws power from the DC power source, VBUS. The power sensor **16** thus serves to indicate whether or not the HID lamp **11** has ignited. The ignition pulse control circuit **14** is responsively coupled to the power sensor **16** so as to cease operation when the power sensor **16** senses that the HID lamp **11** has ignited. For the sake of completeness, although not relevant to the igniter circuit per se, the power sensor **16** serves a second function in that the power supply **15** includes a power regulator (not shown) that is responsive to the power sensed by the power sensor **16** for stabilizing the nominal power to the lamp **11**.

FIG. **2** is a schematic circuit diagram showing in detail a preferred embodiment of the igniter circuit **10** shown in FIG. **1**.

Resonant Ignition Circuit

The oscillator **13** comprises a drive transformer T**1** having first, second and third windings **20**, **21** and **22**, respectively, which are connected in the correct polarity for positive feedback (oscillation). A first end of the first winding **20** is coupled to the source terminal of a first MOSFET M**1** whose gate terminal is coupled via a resistor R**1** to a second end of the first winding **20**. The drain terminal of the first MOSFET M**1** is coupled to VBUS, typically having a voltage of 400 VDC. A pair of zener diodes D**1** and D**2** is coupled back to back across the first winding **20**, their anodes being commonly connected and their respective cathodes being connected to opposite ends of the first winding **20**. The zener diodes D**1**, D**2**, limit the gate voltage fed to the MOSFET M**1** and thereby ensure that when the resonant voltage increases, it does not damage the gate of the MOSFET M**1**.

In complementary trimmer, the first end of the second winding **21** is coupled via a resistor R**2** to the gate terminal of a second MOSFET M**2** whose source terminal is coupled to a second end of the second winding **21** and constitutes the ground rail, GND. The drain terminal of the second MOSFET M**2** is coupled to the source terminal of the first MOSFET M**1**. A pair of zener diodes D**3** and D**4** is coupled back to back across the first winding **20**, their anodes being commonly connected and their respective cathodes being connected to opposite ends of the second winding **21**. The zener diodes D**3** and D**4** limit the gate voltage fed to the MOSFET M**2** and thereby ensure that when the resonant voltage increases, it does not damage the gate of the MOSFET M**2**. The first end of the second winding **21** is coupled to an 'ON' control output of an ON-OFF splitter **25**, its second end being coupled to GND. An 'OFF' control output of the ON-OFF splitter **25** is connected to the gate of the MOSFET M**2**. An input of the ON-OFF splitter **25** is connected to an output of the ignition pulse control circuit **14**, as will be described in more detail below. The ON-OFF splitter **25** serves to convey an ignition pulse conveyed by the ignition pulse control circuit **14** to the winding **21** of the drive transformer T**1** to enable the oscillation process; and to convey a disable signal to the gate of the MOSFET M**2** to prevent oscillation after the lamp **11** has ignited.

A first end of the third winding **22** of the oscillator drive transformer T**1** is connected to a first capacitor C**1** connected in series with a first end of a resistor R**3**, whose second end is coupled to the common junction of a split winding of a transformer T**2**, comprising windings L**1**, L**2**. The coils L**1** and L**2** are wound such that a first end of the coil L**1** is connected to a second end **23** of the coil L**2**, whose first end is connected to a first end of the HID lamp **11**. A second end of the third winding **22** is connected to the common junction of the two MOSFETs M**1** and M**2**, i.e. to the source of M**1** and to the drain of M**2**.

The DC power source, VBUS, comprises pair of large series connected electrolytic capacitors C**2** and C**4** connected between VBUS and GND, their common junction **24** being connected to a second end of the HID lamp **11** and to the second end of the coil L**1** via a capacitor C**5**. The capacitors C**2** and C**4** serve as storage capacitors for storing DC voltage for powering the controlled self-oscillator **12** and the power supply **15**. The power supply **15** operates as a low frequency square wave current source controlled power shown as **26** in FIG. **2** that is connected to the common junction of the coil L**1** and the capacitor C**5**. The low frequency square wave current source is produced in known manner by an inverter (not shown). Preferably, the inverter is a half-bridge topology of which the capacitors C**2** and C**4** are integral components. The junction of the capacitors C**2** and C**4** and the first end of the coil L**2** constitute output terminals of the igniter circuit **10** across which the HID lamp **11** is coupled.

Having described the topology of the resonant ignition circuit **12**, its operation will now be described.

The resonant ignition circuit is constituted by M**1** and M**2**, R**1**, R**2**, D**1**, D**2**, D**3**, D**4**, T**1**, C**1**, R**3**, L**1**, C**4** (short), C**5** (short) and its resonant frequency f_0 is determined by C**1**, L**1** in accordance with the equation:

$$f_0 = \frac{1}{2\pi\sqrt{L1 \cdot C1}}$$

C**4** and C**5** have very low impedance at the resonant frequency and so practically behave as short circuits. The Q factor is determined by the values of R**1**, R**2**, R**3**. The resistors R**1** and R**2** together with the input capacitances of the gates of the two MOSFETs M**1** and M**2** create a phase shift which causes a reduction in the resonant voltage fed to the lamp.

The Q factor determines the maximum peak voltage that may be fed to the HID lamp **11** before breakdown, which may be several kilovolts, whereafter the voltage fed to the lamp falls to a low voltage, typically in the order of 20V and is maintained at constant current until it reaches the nominal power of the lamp.

A train of ignition pulses shown graphically in FIG. **3** at the resonant frequency f_0 is fed to the junction between the source of M**1** and the drain of M**2** through the resonant circuit constituted by C**1** and L**1**, so that the resonant circuit resonates with increasing amplitude for the duration of each ignition pulse as shown graphically in FIG. **4** due to the positive feedback produced by the windings of the drive transformer, T**1**. At the end of each ignition pulse, the amplitude of the resonant lamp voltage decreases until it reaches substantially zero until the arrival of the next ignition pulse, when the cycle is repeated. As noted, C**4** has low impedance at the resonant frequency and acts as a short circuit.

When the lamp **11** starts to conduct, the lamp acts as a low impedance, and the current through the lamp fed by the low frequency current source **26** (corresponding to the power supply **15** shown in FIG. **1**) flows through L**1** and L**2** which together operate as a choke, which filters some of the high frequency ripple. C**5** acts as a first filter for removing the high frequency ripple superimposed on the low frequency current. C**2** and C**4** whose mid-point voltage is equal to half VBUS form part of a half bridge inverter that serves to supply low frequency current to the lamp **11** after ignition; and are thus integral components of the power supply shown as **15** in FIG. **1** and of the low frequency current source shown as **26** in FIG. **2**.

Before lamp breakdown, the transformer T**2** serves as the lamp igniter; and after breakdown when the lamp starts to conduct in the current mode, it serves as a choke for removing the high frequency ripple.

The object is to generate a high voltage waveform with increasing amplitude that is applied to the lamp as shown graphically in FIG. **4**. When the lamp voltage reaches a certain voltage (1 kV-4 kV depending on lamp temperature), the lamp ignites. When this happens, the lamp impedance falls to a low value and loads the resonant circuit so that its Q factor falls significantly and it stops resonating. The self-oscillation circuit stops the oscillator coil T**1** from oscillating.

Ignition Pulse Control Circuit

As noted above, the oscillator **13** stops oscillating when the HID lamp **11** ignites owing to the fact that the low lamp impedance after ignition loads the resonant circuit causing a marked reduction in its Q factor. However, rather than rely on this alone, it is considered preferable to disable the ignition circuit once the lamp has ignited, this being achieved by the igniter pulse control circuit **14**. The igniter pulse control circuit **14** comprises a comparator **27** having a positive input to which a reference voltage signal PREF is fed and having a negative input coupled to the power sensor **16** so as to receive a voltage signal PIN that is proportional to the power across the HID lamp **11**. Ignition pulses shown graphically in FIG. **3** having a duty cycle determined by T_{ON} and T_{OFF} are fed to one input of a 2-input AND-gate **28** while the logic signal at the output of the comparator is fed to the second input of the AND-gate **28**. Before the lamp starts conducting, PIN is low and the comparator output is logic HIGH; the AND-gate **28** therefore conveys the ignition pulses to the ON-OFF splitter **25**. When the lamp ignites, PIN is larger than PREF and the output of the comparator **27** goes to LOW, whereupon the AND-gate **28** stops feeding the ignition pulses to the ON-OFF splitter **25**.

The oscillator **13** is self-controlled to operate at the resonant frequency as determined by C**1** and L**1** such that although differences in the values of C**1** and L**1**, as may occur in mass production owing to component tolerances will give rise to different resonant frequencies, the oscillator **13** will always operate at resonant frequency.

Moreover, the resonant frequency at which the oscillator **13** resonates is also a function of the parasitic capacitance of the wires connecting the HID lamp **11** to the resonant ignition circuit **12**, being a function of their length. Therefore, the oscillator **13** resonates at resonant frequency regardless of the length of the wires connecting the HID lamp **11** to the resonant ignition circuit **12**.

The invention claimed is:

1. An igniter circuit for an HID lamp, the igniter circuit comprising:

a DC input for coupling to a source of DC voltage,

an output for coupling to the HID lamp,

a resonant ignition circuit including:

an oscillator operating at a self-oscillating resonant frequency coupled to said DC input for producing successive bursts of voltage having a frequency equal to the resonant frequency and having an amplitude that increases with time and for feeding said bursts of voltage across the output of the igniter until an HID lamp coupled thereto reaches breakdown, so as to cause the lamp impedance to fall to a low value and load the resonant circuit so that its Q factor falls significantly and stops resonating thereby stopping the oscillator from oscillating;

a current source having a low frequency component and high frequency component;

a transformer comprising a first coil and a second coil connected in series with each other, the second coil being connected in series with the lamp, the first coil being part of the oscillator prior to ignition and, after ignition, serving to block the high frequency component so as to pass the low frequency component to the lamp; and

a first capacitor having a first end coupled to the first coil and having a second end coupled to both the lamp and to a first end of a second capacitor having a second end connected to ground (GND), said first capacitor and second capacitor being configured for passing the high frequency component from the current source to GND.

2. The igniter circuit according to claim **1**, wherein the input includes a pair of storage capacitors that are adapted to store high voltage DC, one of said storage capacitors being constituted by the second capacitor.

3. The igniter circuit according to claim **2**, wherein the pair of storage capacitors serve to connect directly to respective outputs of a half-wave bridge rectifier.

4. The igniter circuit according to claim **3**, wherein said storage capacitors are integral components of an inverter having a half-bridge topology.

5. The igniter circuit according to claims **1**, wherein the ignition pulse control circuit is coupled to a sensor responsive to a function of power across the HID lamp for disabling the high voltage oscillator circuit upon ignition of the HID lamp.

6. The igniter circuit according to claim **1**, wherein the oscillator comprises:

a drive transformer having a first winding, a second winding and a third winding connected for producing positive feedback,

a first end of the first winding being coupled to the source terminal of a first MOSFET whose gate terminal is coupled via a resistor to a second end of the first winding,

the drain terminal of the first MOSFET being coupled to the DC input,

the first end of the second winding being coupled via a resistor to the gate terminal of a second MOSFET whose source terminal is coupled to a second end of the second winding and constitutes a ground rail,

the drain terminal of the second MOSFET being coupled to the source terminal of the first MOSFET,

the first end of the second winding being coupled to an ON control output of an ON-OFF splitter that is adapted to convey an ignition pulse conveyed by the ignition pulse control circuit to the second winding of the drive transformer to enable oscillation; and to convey a disable signal to the gate of the second MOSFET to prevent oscillation after the lamp has ignited,

a second end of the second winding being coupled to GND,

an OFF control output of the ON-OFF splitter being connected to the gate of the second MOSFET,

an input of the ON-OFF splitter being connected to an output of the ignition pulse control circuit,

a first end of the third winding of the oscillator drive transformer being connected to a first capacitor connected in series with a first end of a resistor,

a second end of the resistor being coupled to a common junction of a split winding of a transformer comprising a first coil and a second coil wound such that a first end of the first coil is connected to a second end of the second coil,

a first end of the second coil being connected to a first end of the HID lamp, and

a second end of the third winding being connected to the source of the first MOSFET and to the drain of the second MOSFET.

7. The igniter circuit according to claim **6**, wherein the oscillator further comprises:

a pair of zener diodes coupled back to back across the first winding, their anodes being commonly connected and their respective cathodes being connected to opposite ends of the first winding, and

a pair of zener diodes coupled back to back across the first winding, their anodes being commonly connected and their respective cathodes being connected to opposite ends of the second winding.

8. A method for igniting a HID lamp, the method comprising:

using a self-oscillating resonant circuit connected across the lamp to generate successive bursts of voltage having a frequency equal to the resonant frequency and having an amplitude that increases with time;

applying said bursts of voltage across the HID lamp until the lamp ignites, thereby loading the resonant circuit so that its Q factor falls sufficiently to stop the resonant circuit self-resonating;

providing a current source having a low frequency component and a high frequency component;

feeding the current source to the lamp through a transformer having a first coil and a second coil connected in series with each other and the second coil being connected in series with the lamp;

prior to ignition, using the first coil as part of the oscillator for generating the resonant frequency; and

after ignition, using the first coil as part of a choke for blocking the high frequency component so as to feed the low frequency component of the current source to the lamp for maintaining the lamp operative while filtering the high frequency component.

9. The method according to claim **8**, further including substantially immediately disabling operation of the resonant circuit after lamp ignition.

10. An igniter circuit for an HID lamp, the igniter circuit comprising:

a DC input for coupling to a source of DC voltage,

an output for coupling to the HID lamp,

a resonant ignition circuit operating at a controlled resonant frequency coupled to said DC input for producing successive bursts of voltage having a frequency equal to the resonant frequency and having an amplitude that increases with time and for feeding said bursts of voltage across the output of the igniter until an HID lamp coupled thereto reaches breakdown;

wherein the resonant ignition circuit includes an oscillator controlled by an ignition pulse control circuit coupled thereto and the oscillator comprises:

a drive transformer having a first winding, a second winding and a third winding connected for producing positive feedback,

a first end of the first winding being coupled to the source terminal of a first MOSFET whose gate terminal is coupled via a resistor to a second end of the first winding,

the drain terminal of the first MOSFET being coupled to the DC input,

the first end of the second winding being coupled via a resistor to the gate terminal of a second MOSFET whose source terminal is coupled to a second end of the second winding and constitutes a ground rail,

the drain terminal of the second MOSFET being coupled to the source terminal of the first MOSFET,

the first end of the second winding being coupled to an ON control output of an ON-OFF splitter that is adapted to convey an ignition pulse conveyed by the ignition pulse control circuit to the second winding of the drive transformer to enable oscillation; and to convey a disable signal to the gate of the second MOSFET to prevent oscillation after the lamp has ignited,

a second end of the second winding being coupled to GND,

an OFF control output of the ON-OFF splitter being connected to the gate of the second MOSFET,

an input of the ON-OFF splitter being connected to an output of the ignition pulse control circuit,

a first end of the third winding of the oscillator drive transformer being connected to a first capacitor connected in series with a first end of a resistor,

a second end of the resistor being coupled to a common junction of a split winding of a transformer comprising a first coil and a second coil wound such that a first end of the first coil is connected to a second end of the second coil,

a first end of the second coil being connected to a first end of the HID lamp, and

a second end of the third winding being connected to the source of the first MOSFET and to the drain of the second MOSFET.

11. The igniter circuit according to claim **10**, wherein the oscillator further comprises:

a pair of zener diodes coupled back to back across the first winding, their anodes being commonly connected and their respective cathodes being connected to opposite ends of the first winding, and

a pair of zener diodes coupled back to back across the first winding, their anodes being commonly connected and their respective cathodes being connected to opposite ends of the second winding.

12. The igniter circuit according to claim **10**, wherein the ignition pulse control circuit is coupled to a sensor responsive to a function of power across the HID lamp for disabling the high voltage oscillator circuit upon ignition of the HID lamp.

13. The igniter circuit according to claim **10**, wherein the input includes a pair of storage capacitors that are adapted to store high voltage DC, one of said storage capacitors being constituted by the second capacitor.

14. The igniter circuit according to claim **13**, wherein the pair of storage capacitors serve to connect directly to respective outputs of a half-wave bridge rectifier.

15. The igniter circuit according to claim **13**, wherein said storage capacitors are integral components of an inverter having a half-bridge topology.

16. The igniter circuit according to claims **10**, wherein the ignition pulse control circuit is coupled to a sensor responsive to a function of power across the HID lamp for disabling the high voltage oscillator circuit upon ignition of the HID lamp.

* * * * *